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Quarterly Progress Report  
HCMM Contract  
with the  
U. S. Water Conservation Laboratory

7.9-10007  
CR-157899

1. Order No.: S-40255B
2. Principal Investigator: Ray D. Jackson  
U. S. Water Conservation Laboratory  
4331 East Broadway  
Phoenix, Arizona 85040
3. Period of Report: 1 AUG to 31 OCT 78
4. Description:

- a. General. As was mentioned in our last report, a striking feature of crop temperatures measured from low-level aircraft is the significant temperature differences observed depending upon the direction of flight. Thermal images from 16 May 78, one week prior to harvest, are shown in Figure 1 for an east to west pass over the experimental site at 1300 h, and in Figure 2 for a north to south overflight just 5 minutes later. Certain common features can be seen in both images: the warm gravel road along the bottom edge; the one-lane dirt road running east-west in the center; several valleys and drainage areas with a general north-south orientation; and the site of our trailers and portable building at the west end of the dirt road. Other features are recognizable but not easily describable in a few words.

The north half of Figure 1 is generally warmer than the south half, whereas in Figure 2, the east half is warmer than the west half. One possible explanation of these differences is that at the time of the overflights, the south- and west-facing sides of the hills are warmer than the north- and east-facing slopes, mainly because of the solar zenith angle. As the aircraft flies from east to west the scanner is looking normal to the south- and north-facing slopes, and as it flies south to north, the scanner looks normal to the east and west slopes. Note that there are temperature differences of as much as 4 C to 5 C for the same area depending on which direction the aircraft was flying when the data were taken.

Looking at one thermal image, one can see a difference of 10 C between different locations over the entire area. The variability

ORIGINAL CONTAINS  
COLOR ILLUSTRATIONS

HC M-005

RECEIVED

NOV 20 1978

SIS/902.6

Original photography may be purchased from:  
EROS Data Center

Sioux Falls, SD 57198

N79-13428  
Unclas  
G3/43 00007  
(E79-10007) HCMM HEAT CAPACITY MAPPING  
MISSION Quarterly Progress Report, 1 Aug. -  
31 Oct. 1978 (Agricultural Research Service)  
7 p HC A02/ME A01 CSCI 02C

on the ground, at least in our situation, is tremendous. This points out the necessity of taking many ground-based measurements, in the absence of aircraft support, so that the proper inferences can be drawn from the data collected.

Temperature data were divided into 10, 40, 160, and 640-acre blocks. The maximum, minimum, mean, and standard deviation were calculated for all pixels within each block. Figure 3 contains data from the east-west pass and is comparable to Figure 1. In the figure it can be seen that the mean temperatures of the various areas are essentially the same down to the 10-acre blocks. However, the variability of the mean temperatures in the 10-acre blocks ranges from 31.4 C to 36.8 C. Had the next smaller size blocks (2.5 acres) been taken, more variability would have been observed.

Figure 4 shows the data taken from the north-south pass of the aircraft. These data correspond to Figure 2. The observations noted in Figure 3 hold for this figure also. Furthermore, the mean temperature for comparable blocks between both figures are similar. This indicates that under the conditions existing when the thermal images were taken, it was immaterial which direction the aircraft flew if only mean temperatures were to be used for further analysis. This is an important point if the data are to be used for yield predictions.

- b. Problems. No major problems.
- c. Accomplishments. None as yet.
- d. Significant Results. Thermal imagery shows a large temperature variation over the 640-acre experimental site. The variation is due to slope and aspect of the terrain as well as the aircraft flight direction (east-west versus north-south). In spite of these individual temperature differences, mean temperature values from 40 to 640 acre blocks are essentially identical regardless of aircraft flight direction.
- e. Publications. None as yet.
- f. Recommendations. None.
- g. Funds expended. \$1,381 this period; \$43,740 total since 1 NOV 77.

h. Data utility. No spacecraft data available.

Submitted by:

A handwritten signature in cursive script, appearing to read "Ray D. Jackson".

Ray D. Jackson  
Principal Investigator

# Apparent Temperatures (°C)

## 640 acre block (259 hectares)

Maximum = 45.1

Minimum = 19.2

Mean = 33.1

Standard Deviation = 4.6

## 160 acre blocks (64.7 hectares)

41.6

19.2

33.8

3.3

45.1

27.7

34.7

4.2

39.3

25.1

31.6

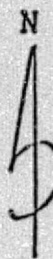
2.9

38.0

24.8

32.3

1.9



Date 5-16-75

Time 12:55

Direction E-W

FIGURE 3

## 40 Acre Blocks (16.2 hectares)

40.9	41.6	44.2	45.1
27.8	29.9	28.9	29.6
33.9	34.0	34.1	35.6
2.8	1.4	2.4	5.3
40.9	40.7	42.1	44.8
27.4	19.2	27.4	28.1
33.7	33.8	34.5	34.7
4.4	4.4	3.2	4.4
38.4	39.3	37.1	38.0
26.0	26.6	24.8	26.9
32.0	32.1	32.4	33.2
3.1	2.8	2.5	1.7
35.3	36.9	36.8	36.5
25.9	25.1	26.3	27.8
31.7	30.5	31.4	32.1
2.8	1.2	1.1	.1

## 10 Acre Blocks (4 hectares)

40.9	38.1	38.4	40.0	37.4	42.2	41.3	42.4
29.3	31.0	30.4	28.9	24.5	26.9	23.6	30.7
33.4	33.9	33.9	33.8	33.6	34.2	24.8	36.9
3.5	1.1	1.1	1.4	1.3	3.3	4.6	5.9
39.5	34.7	38.6	41.6	38.9	44.2	40.1	45.1
27.8	28.9	29.3	30.1	29.9	29.3	29.6	31.9
33.4	34.5	32.9	34.4	34.0	34.5	34.4	36.3
3.7	2.2	1.3	1.8	1.5	3.3	2.3	4.4
40.10	40.4	40.7	41.0	40.9	42.1	41.8	44.8
27.5	27.4	28.9	28.9	27.9	31.0	28.1	27.5
33.9	34.0	34.3	34.1	34.7	35.3	34.9	35.1
4.7	4.4	4.0	2.3	2.8	2.6	5.0	4.5
40.6	39.8	39.5	38.9	40.1	40.3	42.2	40.3
28.1	27.4	19.2	25.7	27.9	29.5	29.2	29.5
33.3	33.7	33.2	33.7	33.9	34.4	31.5	24.2
4.7	3.3	3.3	4.1	2.9	3.2	5.1	2.4
37.5	38.4	34.3	38.9	38.4	34.1	38.0	38.1
26.5	26.8	26.6	26.6	25.4	27.8	27.3	27.4
31.7	33.0	32.0	32.8	32.3	33.3	33.3	32.7
2.7	2.4	4.0	2.1	3.5	1.5	2.0	1.8
36.9	36.6	37.2	35.7	36.5	36.0	36.4	36.6
36.0	29.2	28.6	29.7	29.8	28.3	27.3	27.1
31.0	32.1	31.7	32.0	31.6	33.6	32.5	32.1
2.0	1.2	2.3	1.3	2.1	1.4	1.1	1.1
36.3	35.3	35.4	34.0	35.3	35.7	35.0	35.1
27.8	26.0	26.0	26.1	26.1	26.3	26.3	26.3
32.5	31.4	30.0	30.8	31.6	31.5	32.3	32.3
1.1	2.3	2.0	3.4	1.1	2.8	2.1	2.1
38.1	38.3	38.4	38.1	34.8	33.4	36.5	34.5
25.4	26.2	25.6	27.4	28.3	24.9	27.8	28.4
31.1	31.8	30.6	30.1	31.3	31.4	31.5	32.2
4.8	1.0	0.7	1.0	0.6	0.5	1.00	13.3

Scale: .

1 cm = 660 ft

1 cm = 201 m



# Apparent Temperatures (°C)

640 acre block (259 hectares)

Maximum = 45.1

Minimum = 19.2

Mean = 33.1

Standard Deviation = 4.6

160 acre blocks (64.7 hectares)

41.6

19.2

33.8

3.3

45.1

27.7

34.7

4.2

39.3

25.1

31.6

2.9

38.0

24.8

32.3

1.9

N

Date 5-16-73

Time 12:55

Direction E-SE

FIGURE 3

40 Acre Blocks (16.2 hectares)

40.9	41.6	44.2	45.1
27.8	29.9	28.9	29.6
33.9	34.5	34.1	35.6
2.8	1.4	2.4	5.3
40.9	40.7	42.1	44.8
27.4	19.2	27.4	28.1
33.7	33.8	34.5	34.7
4.4	4.4	3.2	4.4
38.4	39.3	37.1	38.0
26.0	26.6	24.8	26.9
32.0	32.1	32.4	33.2
3.1	2.2	2.5	1.1
38.3	36.9	36.8	36.5
25.9	25.1	26.3	27.8
31.7	30.5	31.4	32.1
2.8	1.2	1.1	.1

10 Acre Blocks (4 hectares)

40.9	38.1	38.4	40.0	37.4	42.2	43.3	42.4
29.3	31.0	30.4	28.9	24.5	26.9	24.6	30.7
33.4	33.9	33.9	33.6	33.6	34.2	34.8	36.9
3.5	1.1	1.1	1.4	1.3	3.3	4.6	5.9
39.5	34.7	32.6	41.6	38.9	44.2	40.1	45.1
27.8	26.9	29.3	30.1	29.9	29.3	29.6	31.9
33.4	34.5	32.9	34.4	34.0	34.5	34.4	36.8
3.7	2.2	1.3	1.8	1.5	3.2	2.3	4.4
40.10	40.4	40.7	41.0	40.4	42.1	41.8	44.8
27.5	21.4	26.9	26.9	27.9	31.0	28.1	24.5
33.9	24.0	34.3	34.1	34.7	35.3	34.9	35.4
4.7	2.4	4.0	2.3	2.8	2.6	5.0	1.5
40.6	39.8	39.5	38.9	40.3	42.2	43.3	43.3
28.1	27.4	19.2	25.7	21.4	27.5	29.2	24.5
33.3	33.7	33.2	33.7	34.4	34.5	34.5	34.2
4.7	3.4	6.3	4.1	2.9	3.2	2.1	2.4
37.5	32.4	31.3	32.4	30.4	37.1	36.0	38.1
26.6	26.0	26.8	26.6	26.4	27.8	27.3	26.4
31.7	33.0	32.0	32.8	32.3	33.3	33.3	33.9
2.4	2.4	1.0	2.1	3.5	1.5	2.0	1.8
36.9	36.6	37.2	35.7	36.5	36.0	36.4	36.6
26.0	29.2	28.6	27.7	24.8	26.3	26.3	26.1
31.0	22.1	31.7	32.0	31.0	33.2	32.5	32.1
2.0	1.2	2.3	1.3	2.1	1.4	1.1	1.1
36.3	35.3	35.1	34.0	35.3	35.4	35.0	35.1
27.8	26.0	26.6	26.6	27.1	26.3	26.4	26.4
37.5	31.4	30.8	30.8	31.6	31.3	31.3	31.3
1.1	2.3	2.0	3.3	1.0	2.3	3.1	2.1
38.1	38.3	38.1	35.1	34.7	33.1	36.5	31.5
25.4	26.2	26.6	27.4	27.3	24.9	24.9	24.4
31.1	31.8	30.6	30.1	31.3	31.4	31.3	32.2
4.4	1.0	0.7	1.0	0.5	0.5	1.0	43.2

Scale:

1 cm = 660 ft

1 cm = 201 m





# 640 acre block (259 hectares)

Maximum = 45.6

Minimum = 22.5

Mean = 32.8

Standard Deviation = 3.6

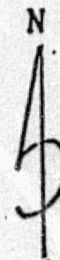
# 160 acre blocks (64.7 hectares)

41.5  
24.1  
32.0  
2.5

45.6  
26.3  
34.0  
3.2

39.3  
22.5  
31.6  
2.0

39.7  
26.4  
33.7  
2.5



Date 5-16-78

Time 1355

Direction S-N

# 40 Acre Blocks (16.2 hectares)

37.5 27.1 31.7 2.0	41.1 27.8 32.6 1.9	41.3 28.1 33.8 2.3	45.6 26.3 34.0 3.5
37.5 26.3 31.6 2.1	41.5 24.1 32.2 3.5	41.3 27.9 34.0 3.2	42.1 26.9 34.2 3.9
35.7 27.3 31.7 1.5	39.3 22.5 31.5 2.5	39.7 26.4 33.3 4.1	38.8 28.6 33.7 1.6
32.5 26.4 31.4 1.6	36.9 23.5 31.7 2.2	39.7 27.4 33.9 2.3	32.2 27.9 34.0 1.5

# 10 Acre Blocks (4 hectares)

37.5 27.6 31.5 2.0	37.2 27.4 32.4 1.4	37.4 27.3 32.3 1.4	38.5 28.8 33.0 2.1	41.3 27.1 33.7 2.0	37.2 28.1 33.7 2.9	44.0 28.3 34.2 3.9	46.0 26.3 34.0 2.6
35.4 27.1 30.9 2.1	36.5 27.9 32.1 1.3	37.6 28.5 32.3 1.5	41.1 29.6 32.3 1.2	40.0 29.8 33.7 1.2	40.0 29.8 34.1 2.9	45.6 28.9 33.9 4.5	39.0 29.1 33.9 4.0
36.7 27.6 31.8 2.0	37.4 26.3 31.4 2.2	37.7 24.5 32.0 3.2	41.5 28.3 32.9 2.1	41.3 28.6 31.6 3.5	37.5 29.1 34.8 2.2	41.5 29.4 35.1 4.9	40.3 29.6 33.8 3.0
36.5 26.6 27.7 1.2	37.5 26.9 31.4 2.7	36.7 24.1 31.7 4.0	38.5 24.6 32.4 2.8	37.6 28.6 33.3 2.0	40.5 29.6 34.3 3.6	40.5 29.3 34.0 2.8	42.1 26.9 33.9 4.5
34.9 27.3 31.5 0.9	35.7 27.3 32.2 2.1	34.3 27.5 31.0 3.9	36.5 26.3 32.0 1.2	38.0 26.8 32.3 4.0	37.5 28.4 33.7 2.8	38.5 29.6 33.6 2.1	37.8 21.4 33.4 1.6
35.0 22.4 31.4 0.7	35.7 27.4 31.7 1.7	36.7 27.3 31.0 2.1	38.5 28.4 32.1 1.3	37.6 26.4 32.2 2.2	40.5 28.1 34.3 1.2	38.5 29.7 34.0 1.2	42.1 27.2 33.7 1.2
35.4 26.4 30.9 2.3	36.9 27.5 31.7 2.0	36.7 26.1 31.4 1.7	38.5 27.4 32.1 1.7	37.6 27.4 33.7 1.6	40.5 29.4 33.5 4.0	38.5 29.6 34.0 1.2	42.1 27.4 33.4 1.3
36.5 26.4 31.7 0.6	34.5 27.9 31.6 0.8	36.4 25.5 30.8 1.3	38.9 26.4 32.6 2.3	37.9 25.2 34.1 1.4	38.4 29.3 34.1 1.5	38.2 27.7 34.6 1.2	36.4 21.3 33.8 2.7

Scale:

1 cm = 660 ft

1 cm = 201 m



640 acre block (259 hectares)

Maximum = 45.6
Minimum = 22.5
Mean = 32.8
Standard Deviation = 3.6

160 acre blocks (64.7 hectares)

41.5 24.1 32.0 2.5	45.6 26.3 34.0 3.2
39.3 22.5 31.6 2.0	39.7 26.4 33.7 2.5



Date 5-16-78

Time 1355

Direction S-N

FIGURE 4

40 Acre Blocks (16.2 hectares)

37.5 27.1 31.7 2.0	41.1 29.8 32.6 1.9	41.3 28.1 32.8 2.3	45.6 26.3 34.0 3.5
37.5 26.3 31.6 2.1	41.5 24.1 32.2 3.5	41.3 29.9 34.0 3.2	42.1 26.9 34.2 3.9
35.7 27.3 31.7 1.5	39.3 22.5 31.5 2.5	39.7 26.4 33.3 4.1	38.8 28.6 33.7 1.6
32.5 26.4 31.4 1.6	36.9 25.5 31.7 2.2	39.7 27.4 33.9 2.3	38.2 29.9 34.0 1.5

10 Acre Blocks (4 hectares)

37.5 27.1 31.5 2.0	37.2 29.4 32.4 1.4	37.4 28.8 32.3 1.4	38.5 28.8 33.0 2.1	41.3 27.1 33.1 2.0	37.2 28.1 33.7 2.9	44.6 28.3 34.2 3.9	40.0 26.3 34.0 2.6
35.4 27.1 30.9 2.1	36.5 29.4 32.1 1.3	37.6 28.1 32.2 1.5	41.1 28.4 32.1 1.2	40.0 29.8 33.7 1.2	40.0 29.8 33.7 2.9	45.6 28.9 33.7 4.5	37.0 29.1 33.9 2.6
36.7 27.6 31.8 2.0	37.4 26.3 31.4 2.2	37.7 24.5 32.0 3.2	41.5 38.3 32.9 2.1	41.3 28.6 32.6 3.5	37.5 29.1 34.8 2.2	41.5 29.4 35.1 4.9	42.3 25.6 33.8 3.0
36.5 26.6 31.7 1.2	37.5 36.9 31.7 2.9	36.7 24.1 21.7 4.0	36.5 24.8 32.4 2.2	37.6 28.6 33.3 2.0	40.3 29.6 34.3 3.6	37.8 27.3 34.0 2.8	41.1 26.9 33.9 4.3
34.9 27.3 31.5 0.9	35.7 24.3 32.2 2.1	34.3 27.5 21.0 3.9	36.5 28.3 22.0 1.2	38.0 26.8 32.3 4.0	37.5 28.9 33.7 2.8	37.5 29.6 33.6 2.1	38.8 28.4 33.4 1.2
35.0 22.4 31.4 0.7	35.7 24.4 31.7 1.7	36.7 27.3 31.0 2.1	36.5 28.4 22.1 1.3	37.5 26.4 32.2 2.0	37.1 28.1 34.5 1.2	36.3 29.1 34.0 1.1	37.1 29.1 34.0 1.2
35.4 26.4 31.4 2.3	35.0 21.5 21.0 2.0	30.1 26.1 31.0 1.7	27.2 20.8 32.1 1.2	37.8 27.4 33.1 1.6	37.0 27.4 33.5 4.0	37.2 27.6 34.2 1.2	37.1 24.4 33.3 1.3
36.5 26.4 31.7 0.6	34.5 21.9 31.6 0.7	35.4 25.5 30.8 1.3	31.7 28.4 32.6 2.3	37.7 26.2 24.1 1.4	37.4 29.3 34.1 1.5	38.2 27.7 34.6 1.2	36.4 21.3 33.8 0.5

Scale:

1 cm = 660 ft

1 cm = 201 m

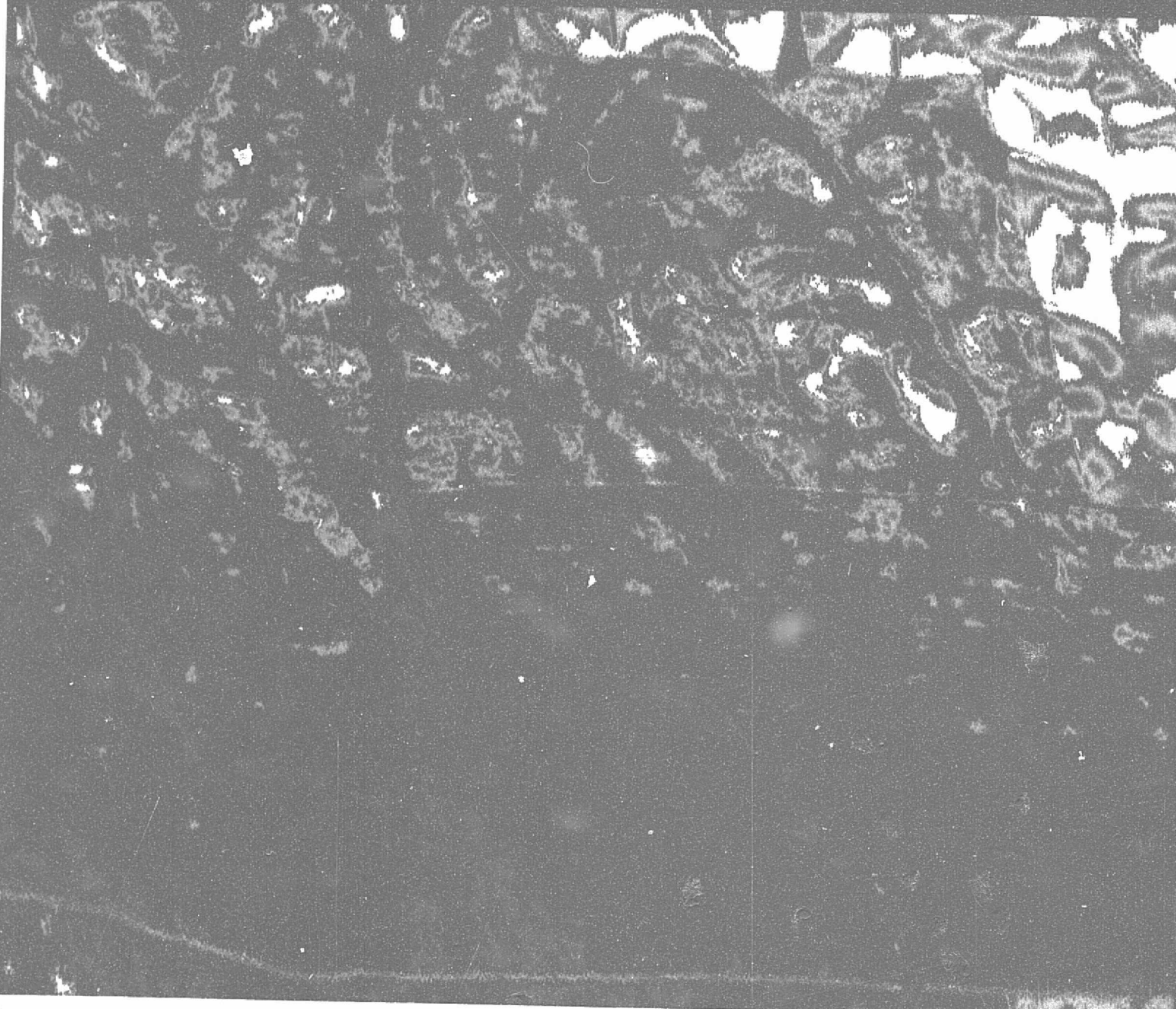




DAME TEST SITE

05/16/78(1300)

EAST-WEST PASS



39

38

37

36

35

34

33

32

31

30

29

28

FIGURE 1

FIGURE 2

